It is a wise plan to move the patient as soon as possible from the room in which he has spent the febrile stage of the disease, and when he is sufficiently strong to allow him to spend the morning in one room and the afternoon in another with a different exposure, getting the benefit of the sun in both.

In this paper I have not attempted to cover the whole field of nursing in typhoid, but only to touch upon some points which I have found by experience to be of much importance, and which are not always sufficiently brought out in our text-books or lectures.

THE PHYSIOLOGICAL BASIS OF HYDROTHERAPY

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Hydrotherapy is the systematic use of water of varying temperatures as a curative agent. Undoubtedly much misunderstanding has arisen with regard to the phrase hydrotherapy, or water-cure, since the value of water depends not so much upon itself as upon its capacity for heat or heat conduction. It is the most convenient medium we have for controlling the withdrawal or addition of heat to the body. Indeed, the term thermotherapy might better be used, since practically it is the varying degree of heat or cold employed which accomplishes the purpose. Heat and cold are but relative terms of the same energy, considered from the stand-point of normal body-temperature. Air or vapor might serve the purpose—and, indeed, hydrotherapy is supplemented by hot-air or vapor baths. But water has a capacity for heat four times that of air and is therefore more efficient for modifying body-temperature. Therefore let it be well understood that it is through the modification of the heat of the body primarily that we secure the therapeutic result.

The varying degrees of heat and cold may be arbitrarily expressed as follows: Cold signifies a temperature below 65° F.; cool, between 65° and 80°; tepid, between 80° and 90°; warm or neutral, between 90° and 100°; hot, above 100°. Very hot or very cold indicate extremes of temperature.

The physiological basis of hydrotherapy, then, depends upon its influence on the production and elimination of animal heat.

Animal heat is the resultant effect chiefly of oxidization—metabolism, so called. This largely takes place in the capillary system.

Certain other physical processes are also a source of heat, such as the secretion of glands, contraction of muscles, and mental exertion. If no heat were given off, the body would become very hot in a short time. But heat equilibrium is preserved through its elimination by the skin. Indeed, one very important function of this organ consists in the maintenance of this heat equilibrium.

Hence we formulate a simple ratio which may help us to understand the physiological action of hydrotherapy.

Under normal conditions heat production equals heat elimination. Increased heat production necessitates increased heat elimination. Diminished heat production lessens heat elimination. The reverse of this equation is also true. Through the use of water of suitable temperatures we can regulate heat loss, and therefore in a measure control heat production.

Cold water removes heat rapidly, therefore heat production is stimulated to maintain the equilibrium and the nervous system rendered more active—a tonic effect. Conversely, warm water interferes with the escape of body-heat, or, if above the body-temperature, may even increase the natural heat. This results in checking heat production in the body. It retards tissue change, slows nervous action, and is sedative. If, however, we are dealing with abnormal conditions,—febrile for example,—our formula is somewhat modified. The skin is dry, perspiration is checked, and the escape of heat is not rapid enough to preserve normal heat equilibrium. Therefore the temperature of the body rises. Hence, if we wish to establish the normal equilibrium, we must check the morbidly excessive heat accumulation by increasing the loss of heat. This is done by a cold bath—the so-called Brand method of treating typhoid fever—and is based upon sound reasoning. Or, again, how gratifying it is to see a feverish patient break out into a gentle perspiration, because thereby the heat equilibrium is restored and the fever "broken." On the other hand, conditions of lowered heat production or of excessive heat loss result in depressed and sluggish states of the nervous system, which can be remedied by increasing the one or diminishing the other by proper procedures.

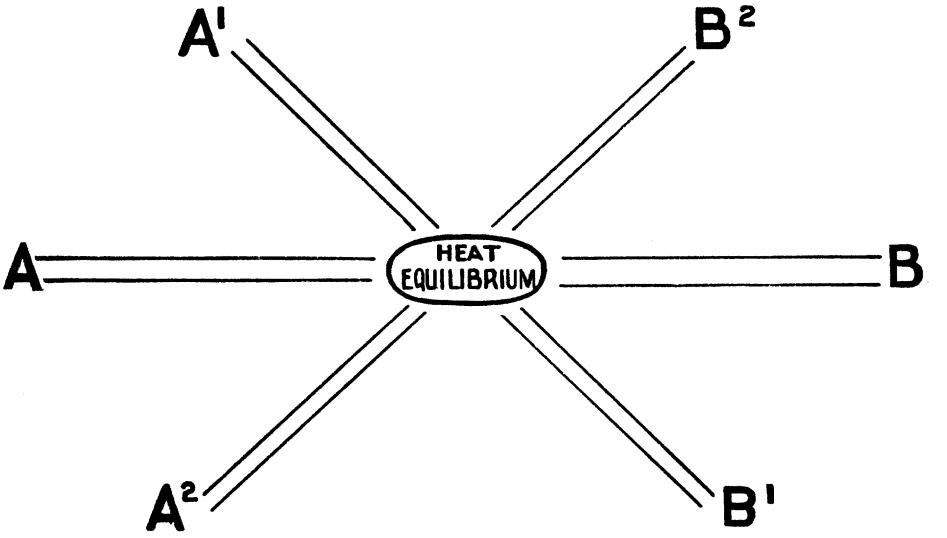
In the one case the subnormal condition, as in neurasthenic states, may be benefited by cold water, which stimulates heat production. Or, again, the heat equilibrium may be gained by retarding the loss of heat through warm baths.

Thus by modifying our hydrotherapeutic measures we may control any one of these simple factors of the body-heat and secure tonic, sedative, or antipyretic effects.

This may be graphically represented by the subjoined diagram, in

which A represents normal heat production and B normal heat elimination.

A^1 = heat production increased;
A^2 = heat production diminished;
B^1 = heat elimination increased;
B^2 = heat elimination diminished.



If A is elevated to A^1, B must become B^1 to establish natural conditions; or if B becomes B^2, A must be lowered to A^2 for the same reason. The reverse is true as well. Otherwise elevation of A to A^1 or of B to B^2 disturbs the equilibrium and raises the body-temperature. In the same way lowering A to A^2 or B to B^1 reduces the body-temperature.

Furthermore, increased body-heat causes the peripheral blood-vessels to dilate, thus draining the blood from the deeper structures—the brain, for instance. Hence the value of a warm bath slightly above the temperature of the skin. By increasing the body-heat dilatation of the skin capillaries ensues through the effort the system makes to re-establish heat equilibrium. The skin then not only has a tactile and secretory function, but it also has an extensive network of capillaries for the dissipation of heat. This dissipation of heat is accomplished not only by direct conduction, but even more by perspiration, sensible and insensible. It is also richly endowed with nerve-fibrils, through the excitation of which by heat or cold deeper structures are affected and the so-called "reaction" secured. The nerve-supply of the skin is much greater than that of the mucous surfaces—a matter which explains the

greater tolerance of mucous surfaces to more extreme temperatures. It is for this reason that in using a very hot vaginal douche it often is necessary to protect the perineum and adjoining skin.

Heat and cold applied to the cutaneous surfaces produce certain effects due either to simple contact, to cutaneous evaporation, to direct action upon the local circulation, or to reflex influence upon the nervous system. The most intense influences are produced by alternating hot and cold applications.

Following the immediate effects of the application of heat or cold, we observe secondary phenomena quite the opposite: the so-called "reaction"—which is perhaps the most salutary result of hydrotherapy and to which we shall allude later.

Let us now consider the effect of heat upon the various functions of the organism.

Cutaneous secretions are increased. *Tactile sensibility* is at first increased, then diminished, hence the temperature of an application can be gradually raised within the limit of toleration. High temperature diminishes sensibility.

Circulation.—Heat accelerates the heart-action, although momentarily it may slow it. The individual heart-beat is weakened and blood-pressure lowered. The capillaries are momentarily contracted, but dilatation almost immediately ensues. Through dilatation of the capillaries of the skin moderate heat exercises a valuable derivative influence upon central congestion. Hence the value of prolonged warm baths in mania and similar conditions.

Muscular System.—Moderate heat increases muscular contractility; prolonged or very high heat diminishes contractility. For this reason in warm weather muscular activity is freer.

Nervous System.—High temperature excites the nervous system, while moderate heat is a calmative.

In general the influence of heat is sedative to the circulation, relaxing to the muscles, and calmative to the nervous system. In selecting the mode of applying heat it should be borne in mind that the warm douche is more speedy in its effect, more simple in its application, and more easily regulated. Four or five minutes of the douche is equal to half an hour's bath, while the force of the douche is slightly tonic in its action.

Cold, however, is a more important agent in hydrotherapy than heat and merits careful attention. In a general way, the lower the temperature the briefer should be the application. The extent of surface involved should also be considered as a factor. However, by degrees one may become accustomed to a very low temperature.

Tactile sensibility is reduced, although at first the shock may be painful. The rate of transmission is ten times less at a temperature of thirty-two degrees than at a temperature of the body, at which point the rate is about two hundred and forty feet per second. Hence immersion in cold water is less disagreeable when quick than when slow. The same is true when cold water is applied, as in a douche, in a fine, strong stream. The needle spray is better borne than the shower.

Body-heat is lowered and heat production therefore stimulated. If the application is unduly long, heat equilibrium is not easily preserved, and chills—clonic muscle contraction—or even cramps—tonic contraction—result in the effort the system makes to increase heat production. This effect, of course, in excess is injurious and should be avoided. If, however, the application is brief, the energetic production of body-heat more than compensates for the heat loss, and the surface temperature may even be raised above the normal—the reaction. This is more pronounced the colder the water, the shorter the duration of the application, and the more energetic its force—other things being equal.

The *circulation* is slowed by cold. The heart, at first quickened by the shock stimulus, beats slower, although each contraction is stronger. Arterial tension is increased. This is quite contrary to the action of heat.

Muscular System.—Cold increases contractility of both the smooth and striated muscular fibres. If, however, the application is prolonged or very cold, muscular contractility is diminished and may disappear. One readily recalls the loss of muscular activity when "half frozen."

Digestion and Secretions.—Under the influence of cold the appetite is increased, peristaltic action becomes more energetic, and metabolism, or tissue-change, stimulated. Hence the tonic influence of winter, the enervating effect of summer. Within certain limits the more pronounced the cold, the greater the acceleration of tissue-change. This primary effect, however, is neither very pronounced nor lasting. As Voit facetiously remarks, "Reflex metabolism is not sufficient in itself to keep the inhabitants of the Arctic regions from freezing, nor does it enable mankind in a temperate climate to discard clothing."

Nervous System.—The subtraction of heat is benumbing to nervous action. However, through the sensory nerves the cold application acts as an irritant, resulting in reflex motor or secretory activity. This reflex action affects the areas directly exposed to the cold and also other portions of the body which may be associated with these areas through the nervous system. For example, plunging one arm in cold water reduces the temperature also in the other. Or if cold is applied upon one breast, "goose-flesh" appears on the other. This is taken advantage of

in local applications of cold or heat to affect deeper organs, as the brain, stomach, uterus or other abdominal structures. Thus a spinal ice-bag between the shoulders over the cervical region will relieve the sense of "headfulness," or even headache, owing to this reflex nervous action. This, of course, is largely due to vasomotor influences and enables one to secure revulsive effects in congested organs far removed from the direct action of the application.

In general, cold strengthens the circulation, intensifies the tone of the muscles, and stimulates nervous activity. It is a tonic, while heat is a sedative. Of all modes of application the cold douche, which can easily be regulated as to size, temperature, force, and duration, is most favored within proper limits. It is effective as a tonic: the stronger the stream, the more energetic the force and the lower the temperature. Its duration should be in inverse proportion to its temperature. A very cold application necessarily should be brief.

A few years ago Winternitz, of Vienna, called attention to the influence heat and cold had upon the component parts of the blood. The general application of cold increases the number of red blood-corpuscles—the erythrocytes, the white blood-corpuscles—the leucocytes, and the blood-coloring matter—the hæmoglobin.

Warm baths result at first in a moderate diminution of the erythrocytes, but subsequently in a moderate increase. Local applications of cold are attended by a marked increase in the erythrocytes and the hæmoglobin in the corresponding area, while warm applications develop a corresponding increase of the leucocytes, or white blood-cells, and a diminution of the red blood-cells. This latter circumstance explains in a measure the value of prolonged warm poultices in favoring, or of cold packs in preventing, suppuration.

Following the primary effects which we have described, certain secondary phenomena occur as the result of the reaction of the system to these primary changes—the so-called reaction.

Upon the application of cold water, as, for example, by a douche, there first results a distinct shock with formation of "goose-flesh," accompanied with shivering or, indeed, with chattering of the teeth. There is marked increase in the heart-action, with increased arterial tension, a more frequent pulse, and a more rapid respiration, with pallor of the skin and some contraction of the muscles.

This condition, however, does not last long, the general tension lessens, and the subject experiences a universal glow with a gain of vital energy—the so-called "reaction." The extent of the reaction varies according to the individual and depends somewhat upon the kind of stimulus used and the circumstances of its application. To obtain a

sufficient but not excessive reaction is one of the most important and most difficult tasks of hydrotherapy.

According to Winternitz, this reaction depends upon the following conditions, other things being equal:

1. Within definite limits, the greater the primary loss of heat, the greater the reaction.

2. The more rapid the heat reduction, the more prompt the secondary increase.

3. The longer the application of cold, the slower the reaction. Prolonged and gradual heat reduction result in a slower and less intensive secondary increase in body-heat than short refrigeration at a lower temperature. This is of special importance in the antipyretic use of cold water, where it is desired to secure a prolonged reduction of temperature.

4. Upon the relative quantity of body-heat. A body which is very warm before the application reacts more vigorously than one relatively cool.

5. The preliminary use of warmth or muscular exercise increases the intensity of the result.

A warm douche or hot-air bath before the refrigeration gives a more positive reaction.

6. The employment of mechanical irritation with the application increases the invigorating effect. For example, with the cold bath, friction of the body, or with the douche, increasing the force of the jet, aids the reaction.

7. It is also more prompt and more marked if muscular activity or work is indulged in directly after the procedure, while it is retarded by remaining quiet. The use of stimulants, such as alcohol, also increases the result.

In general the reaction is more decided, the colder the water, the shorter the application, the more elevated the body-heat, the more energetic the force, the higher the temperature of the air, and the more vigorous the subject. An inefficient reaction is indicated by ill consequences, such as peevishness, collapse, pallor, feeble pulse, prolonged chilliness, disturbance of various functions, secondary perspiration, etc. Indeed, injurious results to the nutrition may easily result from inefficient management. A perfect reaction should be secured, in accordance with the indications of each case. In febrile diseases, where an antipyretic effect is desired, it should appear slowly and not become excessive. In chronic disturbances of nutrition or in retarded metabolism prompt and active reaction should be the aim.